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METHOD FOR OPTIMIZED COLOR REPRODUCTION OF A COLORED ORIGINAL IMAGE

5 Various color systems (US 6 281 984 B1) are used for color specification in image processing and image reproduction (for example on a monitor or a printer). While input devices (for example scanners) predominantly designate colors via RGB, the knowledge of the area coverage degree of the primary colors (mostly CMYK) is necessary for color reproduction devices. However, other color reproduction devices such as monitors also use RGB for color specification.

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This problem is explained using Fig. 1. An original image BV is, for example, shown in a first color system (for example RGB) with a scanner SC. The RGB image values for the original image BV are, for example, translated into CIE-LAB image values. The original image should now be output by a color reproduction
15 device, a printer as an example [sic]. The printer operates in a second color system, for example CMYK. The CIE-LAB color values are correspondingly translated into the color system CMYK. The printer WG can now print the original image as BV'.

20 All of these color specifications are device-dependent, i.e., for example, the same RGB values of two different scanners or scanner and monitor describe different colors. This device dependency has been known for a long time. In order to enable a correct color communication between the various devices, a conversion of the device-dependent color specification into a device-independent color system
25 (for example CIELAB) is therefore frequently effected. For this conversion, the color values are typically determined with a color measurement device and associated with the device-dependent color specification (RGB, CMYK). One possibility of such a color association is the creation of tables, as this is implemented in the color profiles according to ICC International COLOR
30 Consortium (address: www.Color.org). Such color profiles are also specified in DE 199 46 585 A1. However, it is just as conceivable to use functions instead of

tables to specify the color association. Color association is discussed in the following for a conversion rule of color specifications, for example between device color specification and an arbitrary color specification (for example CIELAB).

5 What is problematic is that color reproduction devices can in principle not cover the optimal color space, but rather are limited to more or less sizable color ranges. Therefore colors that are not reproducible by the color reproduction device are modified in the color conversion. There are various possibilities for this color adaptation. This, for example, given color management according to ICC four
10 variants of the color association tables are already established by default. For the most part it is attempted to obtain an optimally similar image impression given color images; this color adaptation is called “perceptual” in ICC. Not only are the colors that are not achieved by the respective color reproduction device thereby changed, but rather also those colors lie in the boundary range of the achievable
15 color space. This is necessary in order to obtain a gradation between various colors.

Fig. 2 shows these relationships. Shown there in an xy-graphic (as a part of CIE_xy_y) over the color norm portion x, y is the theoretical optimal maximal color
20 space FR (unbroken curve) and the color space FR-WG (dot-dash curve) achievable by a color reproduction device, for example a printer. Colors are additionally specified as an example. When the color space achievable by an original image is greater than the color space achievable by an original image, a color space adaptation occurs (shown by unbroken arrows). The colors outside of
25 the color space of the color reproduction device are thereby shifted into the color space of the color reproduction device. This compression occurs for all colors lying outside of the color space of the color reproduction device, but also for colors lying within the color space of the color reproduction device in order to obtain the color gradation explained above.

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Many methods of color space adaptation are known. A few examples are found in

- the IS&T Proceedings of the Eighth [sic] Color Imaging Conference, 2000-11-07 through 2000-11-10 in USA, Arizona, Phoenix, Scottsdale, SunBurst Hotel.
- L. MacDonald, J. Morovic, K. Xiado: Topographic gamut mapping algorithm based on experimental observer data; IS&T Proceedings of the Eighth [sic] Color Imaging. Conference, 2000-11-07 through 2000-11-10 in USA, Arizona, Phoenix, Scottsdale, SunBurst Hotel
- H. Motomura: Gamut Mapping using color-categorical weighting [sic] method, IS&T Proceedings, Eighth Color Imaging Conference, 2000-11-07, Scottsdale.

In the known methods, such a color association for each created image-independent for each color reproduction device. This means that all theoretically possible colors must be mapped in the color space of the color reproduction device. However, this also leads to colors that lie within the reproducible color space having to be significantly changed and reduced in terms of their saturation. Given images that do not completely cover this theoretical optimal color space, this leads to an unnecessary modification of the colors of the image. As a rule, given color images only a limited color space is necessary, such that most images are unnecessarily significantly changed.

The conversion of color information ensures that color specifications exist that can be traced over the entire color transfer process. This color value conversion thereby must be determined for each individual device (or device class) and also for different transfer settings (brightness setting on the monitor, paper grade in the printer, etc.). According to methods typical today, this is implemented one time for each device state used.

The problem to be solved by the invention is to specify a method with which original images can be reproduced optimally colorfast with a color reproduction device. Designated with "original image" here are all color images that should be

output by a color reproduction device, independent of their origin. For example, an original image can be a photo that has been scanned or a color image directly generated by a computer. The original image stored in a computer can thereby already have been uncounted [sic] multiple times.

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This problem is solved according to the features of the claim 1.

The color association for the color reproduction device is now generated with the invention, dependent on the original image to be output. The reproduction
10 properties of the color reproduction device are thereby determines via test outputs, as before. A typical correction of the measurement data thereby acquired (averaging, modification of the sampling points) can also be implemented. However, a color space adaptation still does not occur. The necessary color space of the original image is created beforehand, in that the occurring colors are
15 analyzed. This color space information of the original image can also be generated beforehand in the creation of the original image. Only when it has been clarified how the original image should be output, thus for example the color reproduction device, print substrate, settings etc. are set, is the individual color association created between the color values of the original image and of the color
20 reproduction device (mostly in CMYK when the color reproduction device is a printer). This color association then forms the profile of the color reproduction, which can be stored in table form or the color space conversion function.

The advantage of the inventive method thus lies in that the color space adaptation
25 is different dependent on the original image, thus only so much as is necessary for the respective original image is modified by color space adaptation. An improvement of the color reproduction, an increase of the brilliance of the images, a reduction of the color errors in comparison with the original image, an improved color adaptation with various print substrates therewith result.

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The inventive method is particularly advantageous for the creation of “proofs” (= test prints, in which the appearance of the image is simulated given output on the device to be tested). When proof devices (special digital proofers, monitors, etc.) do not completely comprise the color space of the color reproduction device to be
5 adjusted, the proof errors can be reduced to the unavoidable minimum with the specified method. Given many motifs, the possibility simultaneously opens up to get by with proof devices that exhibit a relatively small color space.

Developments of the invention result from the dependent claims.

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The invention is explained further using exemplary embodiments that are shown in Figures.

Thereby shown are:

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Fig. 3 a further representation of the color spaces of original image and color reproduction device for the case that the original image completely falls in the color space of the color reproduction device;

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Fig. 4 a representation of the color spaces of original image and color reproduction device for the case that the original image does not completely fall in the color space of the color reproduction device;

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Fig. 5 a diagram that shows the workflow of the method.

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In Fig. 3, an example is shown in which the color space FR-WG of the color reproduction device completely comprises the color space FR-BV of the original image BV1, i.e. the color reproduction device can generate all colors contained in the original image BV1. A color space compression in the original image is not necessary for this case.

In contrast to this, in Fig. 4 the original image BV2 comprises colors that do not fall in the color space FR-WG of the color reproduction device WG. For example, the blue tones of the original image BV2 cannot be reproduced. A color space compression is therefore only necessary in the blue range. No color adaptation is implemented with the remaining colors.

The workflow of the method can be learned from Fig. 5. The color space that can be achieved by the color reproduction device WG is initially established (step 1). This occurs in a known manner, in that all possible colors (test colors) are output (for example are printed) and then are measured. The association of the addressed color values with the color values of the color reproduction device is subsequently established (step 2). The measurement data can be smoothed in a known manner in step 3. In step 4, the color range that cannot be reproduced by the color reproduction device WG is determined using the color space of the original image BV, which is determined in step 7. In step 9 it is tested whether the color space FR-BV of the original image is larger than the color space FR-WG of the color reproduction device. If the color space of the color reproduction device completely covers the color space of the original image, a standard color conversion can be loaded without color space compression (step 8). This image-independent color conversion is created once beforehand for the color reproduction device in the desired state (for example print substrate). Otherwise the image-dependent color association (for example the image-dependent profile) for the color reproduction device is created in step 5. As specified above, the non-reproducible color range is thereby optimally adapted to the color space of the color reproduction device with a color adaptation method. The original image can henceforth be printed out as an image BV', corresponding to this color association (step 6).

The inventive method is particularly advantageous when a printer, in particular an electrophotographic printer, is used as a color reproduction device.

Reference list

	BV	original image
	SC	scanner
5	RGB	color system
	CIE-LAB	color system
	CMYK	color system
	WG	color reproduction device
	BV'	image generated by the color reproduction device
10	PR	profile of the color reproduction device WG
	FR	maximal color space
	FR-BV	color space of the original image
	FR-WG	color space of the color reproduction device